Name: **Enrolment No:**	UPES UNIVERSITY OF TOMORROW

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES

End Semester Examination, May 2022

Programme Name: B. Tech. CERP **Semester : IV**
Course Name : Mass Transfer I **Time : 03 hrs**
Course Code : CHCE 2020 **Max. Marks : 100**
Nos. of page(s) : 2
Instructions:

(a) For all the problems state the assumptions you consider clearly.

(b) Assume the appropriate value of missing data if any.

(c) The notations/symbols have their usual meanings.

S. No.		Marks	CO
	SECTION A (5 x 4 = 20 marks)		
Q.1	Differentiate between mechanical techniques and mass transfer principles based techniques to separate a liquid mixture.	**4**	**CO1**
Q.2	Write any two difference between heat transfer and mass transfer.	**4**	**CO1**
Q.3	Write four mass transfer operations with one example of each operation	**4**	**CO1**
Q.4	What are the three different frame of reference to express the flux of a diffusing species?	**4**	**CO1**
Q.5	Explain the difference between penetration theory and surface renewal theory of mass transfer	**4**	**CO1**
	SECTION B (4 x 10 = 40 marks)		
Q 4	A stream of nitrogen containing 7.5 % benzene vapor is scrubbed with a nonvolatile absorption oil in a tower at 35°C and 1.2 bar total pressure. The gas-phase mass transfer coefficient is estimated to be $k_G = 9.8 \times 10^{-4}$ kmol/(m^2)(s)(bar). The mole fraction of benzene at the gas-liquid interface is $y_i = 0.01$. Calculate the mass transfer coefficient k_y , k_c and k_Y.	**10**	**CO2**
Q.5	A 0.8 cm diameter bubble of pure CO_2 is injected into an excess well-stirred liquid at 25 °C. The bubble diameter shrinks to 0.2 cm after 80 s. The total pressure is 1 atm and the solubility and diffusivity of CO_2 in water are 1.45 X 10^{-3} mass fraction 1.9 X 10^{-5} cm^2/s respectively. Calculate the average value of mass transfer coefficient, k_L.	**10**	**CO2**
Q.6	A mixture of nitrogen and acetone contains 1.5 mol% of acetone. It is required to absorb 95 % of the acetone from this mixture in a countercurrent tray tower. The total gas input is 30 kmol/h and water enters the tower at arate of 90 kmol/h. The tower	**10**	**CO3**

	operates at 300 K and 1 atm. The equilibrium relation is y = 2.53 x. Determine the number of ideal trays necessary for this separation using graphical method. Validate your result with Kremser Equation.		
Q.7	A gas mixture having 7 mol% of the solute is to be scrubbed in a packed tower at a rate of 70 kmol/h. The solvent, water, is fed at a rate of 80 kmol/h. In the concentration range involved, the solubility of the gas is described by the equation : $$y_A^* = 1.2\, x_A - 0.62\, x_A^2$$ It is desired to absorb 98 % of A present in the feed. Determine the equation of the operating line and the overall gas-phase driving force at a point in the column where the bulk liquid concentration is $x_A = 0.04$.	**10**	**CO3**

SECTION C

(2 x 20 = 40 marks)

Q.8	A mixture of 38 mol% propane, 22.5 mol% iso-butane, and 39.5 mol% n-butane is flashed in a drum. If 50 mol% of the feed vaporizes, estimate the compositions of the liquid and the vapor phases. The K-values at the given conditions are as follow:	**20**	**CO4**

Component	K-value
Propane	1.42
Iso-butane	0.86
n-butane	0.72

Q.9	A mixture of di- and tri-ethylamines containing 55 mole% of the former is fed to a distillation column at a rate of 40 kmol/h. The feed is at its bubble point. The column is to operate at atmospheric pressure and the top product should not have more than 2.5 mol% of the less volatile. Also, not more than 2 % of the diethylamine in the feed should be allowed to leave at the bottom. The reflux to the column is a saturated liquid. Determine (a) the minimum reflux ratio (b) the number of theoretical plates if the actual reflux ratio is 1.4 times the minimum (c) the slopes of the two operating lines (d) the number of theoretical plates if the reflux is a subcooled liquid at such a temperature that one mole of vapor is condensed for twenty moles of reflux. The equilibrium data in terms of the more volatile are	**20**	**CO4**

x	0.02	0.039	0.052	0.065	0.09	0.092	0.14	0.215
y	0.042	0.085	0.124	0.153	0.225	0.243	0.316	0.449
x	0.601	0.782	0.853	0.932	0.985			
y	0.802	0.910	0.948	0.970	0.993			